Using Data Compression to Increase the Bandwith of Existing Tactical Control System – Content Based Compression

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Introduction

The huge investment in military sensors has meant rapid growth in the quality, diversity and quantity of images collected by the variety of military image acquisition systems. This has outpaced existing transmission, storage and retrieval systems. The military requirements for low bandwidth/power, covert operation, high quality transmission for non co-operative imaging and huge data volumes place severe demands on current state-of-the-art technology. At present, effective and timely communication of large imagery is prohibitive. It is slow and it consumes large portions of available communications capacity. Yet the transmission of imagery is becoming an increasingly important and widespread requirement. It is believed that if information cannot be received or delivered in a reasonable time efficiently and effectively then it is pointless to collect it.

Images in their raw form contain vast amounts of data within which a smaller amount of information may be relevant to particular applications, e.g. tactical control, surveillance, target recognition, change detection, underwater mine hunting etc. There is an urgent military need for an 'intelligent' compression approach that will provide an efficient and effective means of transmitting, storing and managing images based on their 'informative' content. This need is apparent across the range of military environments, from beyond line of sight air communications to underwater communications, from intelligence analysis to covert surveillance as well as fixed and deployable command & control systems and tactical control system.

Intelligent Image Compression

The aim of the presentation was to show the benefits in applying the 'intelligent' image compression technique in military application. The idea is to use image understanding to structure the applied compression so as to ensure that the compression process does not corrupt the militarily 'important' information contained within the image, while still attaining high compression ratios. The system characteristics correspond to clearly identified military requirements and has been evaluated in this context.

Scientific and Technical Issues

Content Based Compression It is a novel approach that has been developed at the Defence Evaluation and Research Agency in which the informative content (e.g. the targets) in an image is preserved using lossless compression while the rest of the image is compressed lossily to gain compression ratio. The regions of interest/targets/informative content are identified/cued automatically.

This novel intelligent compression approach is radically different from all existing compression approaches (where images are compressed either losslessly or lossily across the whole image).

The precise gain in performance depends on the application and the informative content of the image. When compared with lossless compression it can provide the same degree of information with a smaller amount of data. When compared with lossy compression it can provide more information for a given amount of data. In general for still imagery the conventional lossy compression can achieve a significantly higher compression ratio (10:1 to 50:1 for still images with tolerable degradation artefacts) than lossless compression (3:1 at best). In this novel approach up to 290:1 compression ratio can be achieved without losing the ability to identify 'Possible' military activity.

Automated Region of Interest/Target Cueing Algorithms Region cueing provides the essential guidance for automatically applying lossless and lossy compression techniques judiciously and intelligently onto the regions/ targets of interests and non-relevant background areas in the image respectively.

In this project four novel region cueing techniques for static imagery have been developed, namely:

- the H-V quadtree based approach;
- the approximate entropy approach;
- phase congruency;
- a fusion based approach.

The H-V quadtree based and the approximate entropy approaches are both general purpose cueing processes. General purpose cueing was developed to overcome the problem of the high variability of content in military imagery. Phase congruency is a novel general purpose technique that is suited to detecting information at finer detail than the other two, this approach shows very promising results but is not mature enough at this stage. The fusion approach was developed to fuse results from all three

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

techniques so as to benefit from the best of each.

Evaluation showed that the assignment of these regions corresponds to the Photographic Interpreters' and Intelligence Analysts' perception of importance.

Video imagery The novel content based approach has also been applied in video imagery. Here the moving target/object is segmented and encoded losslessly, while the static background is compressed lossily using MPEG4. For the video sequence considered an 800:1 compression ratio has been achieved using this approach, c.f. the 50:1 to 200:1 normally achieved for video with tolerable degradation artefacts.

Visualisation of Performance Evaluation

The conventional approach to performance evaluation in image compression is simply to measure compression and signal-to-noise ratios. Application and user based assessment techniques were developed and used to evaluate both the compression and cueing processes. The assessment took into account subjective user evaluation criteria as well as objective criteria.

A novel visualisation approach was developed to show and explore the highly complex performance space taking into account both the subjective and objective measures.

Conclusion

It has been demonstrated that it is more effective to use the limited available communications capacity to transmit images which have been compressed using the intelligent Content Based Compression than current Standard techniques. In the cases of the imagery considered in this project the Content Based approach can achieve usable 290:1 compression, c.f. 3:1 for Standard lossless techniques and 50:1 for Standard lossy techniques.

It has been shown that the required and attainable compression characteristics and ratio are dependent upon the nature of the imagery and the military operational requirements.

The performance visualisation approach developed, which uses objective and subjective performance metrics, is of wide applicability in performance evaluation for military systems.

Discussion – Paper 23

Evaluation issues

Retrieval effectiveness
- Dynamic data source
- User oriented
- Task oriented
- Key word salience – interactive relevance rating

Summarization
- Targeted at the interests of the user
- Summaries first followed by full report

Visualisation
- Show the similarly, duplicate, topic trends
- Want to know inter-relationship

Value in exploiting open source information

Event Stream analysis

Content based video compression

Only concerned with compression ratio, they don't really care what data is preserved and what's been thrown out.

Loss-less still used for images that require detail analysis and or further processing where loss of data would be unacceptable

Preservation of information is very important in some applications.

Draw attention to area that is of interest, area of no consequence can be compressed to meet bandwidth requirements.

Image fusion – structurally combining images not gray scale

Manual annotation
- Outline particular area of interest in an image
- Identify areas that are of extreme interest

Phase congruency

Performance evaluation
Target detection performance
Performance visualisation

Difference between what is data and what is information

Advantage of preserving data in an image – allows you higher compression while maintaining more information

Important elements of generating an effective image, what are the heuristics?